

Problem Solving And Creativity And Design: What Influence Do They Have On Girls' Interest In STEM Subject Areas?

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ABSTRACT

For girls there is a distinct loss in interest, lack of confidence, and decline in positive attitudes toward STEM subject areas that begins early on in their academic experience and increases with age. According to the National Academy of Engineering, students need to begin associating the possibilities in STEM fields with the need for creativity and real world problem solving skills. Recent research has focused on the necessity of emphasizing the use of creativity and design in attracting girls to STEM academic and career fields. Many extra and after school activities (e.g., State Science Fair, math club, environmental club), provide girls with experiential learning that incorporates problem solving and/or creativity and design skills as well as providing investigative opportunities into academic areas that may not be part of the regular school day. Through hierarchical regression analyses, this study examined the extent to which middle and high school girls' ($n = 915$) age, and interest and confidence in a) problem solving and b) creativity and design predicted their interest in four STEM subject areas. A follow up analysis identified the extracurricular activities in which girls with higher interests in problem solving and creativity and design were involved. Results revealed that interest in problem solving was a positive predictor for interest in all four STEM subject areas; whereas, interest in creativity and design was a positive predictor for interest in computers and engineering, but a negative predictor for interest in science.

Keywords: STEM Subjects; Problem-solving; Problem-based Learning; Creativity; Design; Extracurricular

INTRODUCTION

nited States Department of Labor workforce projections for 2018 indicate that nine of the 10 fastest growing occupations will require substantial science or mathematics education (National Science Board, 2010). Science, Technology, Engineering, and Mathematics (STEM) fields play a critical role in shaping culture and economic development through innovation, creativity, and problem solving. According to Bottoms and Uhn (2007), employers are looking for candidates who possess strong STEM backgrounds. If the United States is to remain globally competitive it must improve STEM literacy in the K-12 classroom and commit to a critical initiative of ensuring that all students develop the knowledge and skills to fully participate in the 21st century workforce (NAS, 2010). For students in K-12 to acquire the skills and knowledge necessary to pursue college degrees in STEM programs, it is critical to cultivate their interests in STEM subject areas early in their education (Denissen, Zarrett, & Eccles, 2007; Jeffers, Safferman, & Safferman, 2004; Shuen, et al., 2011). Furthermore, a primary predictor of whether students pursue a STEM career upon completion of high school is their interest in a STEM career at the beginning of high school (Sadler, Sonnert, Hazari, & Tai, 2012). Maintaining interest in STEM subject areas is even more critical for girls. Throughout high school, Sadler et al. (2012) noted that the “percent of males interested in a STEM career remained stable (from 39.5 to 39.7), whereas for females it declined from 15.7 to 12.7” (p. 411).

According to the report *Why so Few* (AAUW, 2010), girls' interest and achievement in STEM subject areas is affected by historical and invalid stereotypes that impact a girl's perception of her ability to perform well in those academic areas. Two stereotypes prevalent in the literature are boys are better at math and science than girls, and science and engineering careers are better suited for males (AAUW, 2010; Andre et al., 1999; Herbert & Stipek, 2005; Jacobs et al., 2002; Simpkins, Davis-Kean, & Eccles, 2006). Research has shown that the gender gap in middle and high school math and science test scores and achievement are no longer statistically significant (AAUW, 2004; Planty et al., 2009). However, for girls there is a distinct loss in interest, lack of confidence, and decline in positive attitudes toward STEM subject areas that begins early on in their academic experience and increases with age (AAUW, 1998; Brotman & Moore, 2008; Catsambis, 1995; Fennema, 2000; Hebert & Stipek, 2005). Miller, Blessing, and Schwartz (2006) found that girls' perceptions toward science are that it is uninteresting and difficult.

RELATED LITERATURE

Research has shown that for STEM subject areas girls learn best in environments that promote collaborative learning, hands-on experiences, creativity, and practical applications (AAUW, 2000; Campbell et al., 2002; Kafai, 1998; Koch, 2002; Wenglinksy, 2000). Given that girls' interest in STEM careers is impacted by their interest in STEM subject areas (Sadler et al., 2012), it is important to distinguish specific skills and activities in K-12 education that help to cultivate girls' interest in STEM subject areas. Problem solving and creativity and design have been identified as essential skills in students' STEM development (Baine, 2009; NAE, 2008). Modi, Schoenberg, and Salmond (2012) found that for girls who are interested in STEM, 87% also indicated an interest in problem solving; compared with those girls not interested in STEM, only 70% indicated an interest in problem solving.

Three pedagogical methods that use a problem solving approach are Problem-based Learning, Project-based science, and anchored instruction. Problem Based Learning (PBL), an instructional method originally developed in medical schools, has become increasingly popular in K-12 and higher education (Hunt, Lockwood-Cooke, & Kelley, 2010; Hmelo-Silver, 2004). University STEM degree programs are also finding success with PBL (e.g., Davis, Lockwood-Cooke, & Hunt, 2011; Hunt et al., 2010). This method of instruction encourages students to work collaboratively in small groups to solve challenging, realistic ill-structured problems. PBL is an iterative process that encourages students to 1) identify the problem; 2) research the problem, determine the root cause(s), and clarify the problem; 3) collaboratively generate alternative possible solutions; 4) assess the strength and weaknesses of the potential solutions; 5) determine the best solution; 6) test the solution; and 7) establish criteria for determining the effectiveness of the solution (Hmelo-Silver, 2004).

Project-based Science (PBS) is a pedagogical method grounded in problem solving experiences specific to scientific inquiry (Krajcik et al., 1998). In this approach, the problem is addressed through the scientific inquiry process (i.e., prediction, observation, explanation). Components of PBS include: 1) a rich, complex driving question that is relevant to students' lives, 2) production of artifacts, 3) student-centered learning, 4) collaboration, 5) accountability, 6) authentic use of technology, 7) interdisciplinary and cross-disciplinary inquiry, 8) extended time frame, and 9) valid and reliable performance-based assessment (Colley, 2008, p. 25).

Anchored instruction is grounded in a story illustrated through visually-rich environments using technology that puts students in the context of a problem. Principles of anchored instruction include: 1) a realistic event, in which the problem is anchored or focused, 2) students take ownership of the problem and determine how to break down the problem into smaller components (sub-problems), and 3) students take on different perspectives or roles to identify solutions (Bransford, Vye, Kinzer, & Risko, 1990). Knowledge gained through anchored instruction is highly transferable to other real life situations.

Common across all problem solving approaches to learning is that the problem and potential solutions are the motivators for student learning. Collaboration is another key aspect to all three problem-solving approaches. Well-devised problems in any of these instructional methods often require students to draw from and apply their knowledge from different content areas and communication skills to generate viable solutions. In addition to drawing knowledge across multidisciplinary subjects, participating in a curriculum with problem-solving experiences fosters higher levels of epistemic and intellectual development in students (King & Kitchener, 1994; Schraw, Dunkle, & Bendixen, 1995).

Regardless of which problem solving instructional method is used, developing problem solving skills foster critical thinking skills and along with creativity serve as cognitive constructs that have been identified as vital to student success in the 21st century. Silva (2008) notes “it is an emphasis on what students can do with knowledge, rather than what units of knowledge they have, that best describes the essence of 21st century skills” (p. 2). Seventy-six percent of business leaders from U.S. companies surveyed about skills necessary for the emerging workforce to navigate the changing global economy indicated that the significance for *problem solving skills* and *creativity* will continue to increase considerably as the complexity of problems in need of solutions grows (Partnership for 21st Century Skills, 2008a). Furthermore, 70% of business leaders reported recently hired high schools students were lacking critical thinking and problem solving skills (Partnership for 21st Century Skills, 2008b).

In addition to problem solving skills, creativity and innovation have also been identified within the 21st Century Skills Framework as the aptitude for creativity is essential for generating innovative solutions. Recent research has focused on the necessity of emphasizing the use of creativity and design in attracting girls to the STEM academic and career fields (NAE, 2006; NAE, 2008; AA, 2011). While science is a process of investigation and inquiry, engineering is a process of design that requires a blend of knowledge and creativity (Katehi, Pearson, & Feder, 2009). “Although engineering is ultimately a creative endeavor, a recent poll shows that only 3 % of U.S. adults perceive engineering as creative” (Harris Interactive, 2004, as cited in Sullivan, 2006, p. 2). Results from the messaging research published in *Changing the Conversation: Messages for Improving Public Understanding of Engineering* (NAE, 2008), indicated that while many students understood that engineers design and build things, they lack awareness about what engineers actually do. Creativity is such an integral component in engineering and the other STEM fields that some are advocating for a re-focus on STEM to include the arts, recognizing that creativity and innovation skills are necessary in STEM programs and fields (White, 2010). According to Diaz and Cox (2012), while it may not be explicit, at the core of hands-on engineering outreach activities at the K-12 level is the concept of the design process. Additionally, outreach programs that use an art-based thematic approach to bridge the gap in familiarizing middle and high school students with engineering concepts are becoming more prevalent (e.g., Asiabanzour, DesChamps-Benke, Wilson, Loerwald, & Gourgey, 2010)

Formal science education has traditionally been identified as the pathway for developing scientific literacy among U.S. youth (Bruyere, Billingsly, & O’Day, 2009). However, Bruyere et al. noted that science achievement can also be enhanced through Informal Science Education (ISE) activities such as extracurricular programs. Recommendations from the report *Under the Microscope: A Decade of Gender Equity Projects* (AAUW, 2004) also emphasized the importance of extracurricular (informal learning environments) STEM activities. Extracurricular activities play a crucial role in developing interest in STEM areas because the outside of normal class time activities are generally self-selected which means that students who choose to participate often have a fundamental interest or curiosity about the subject area or activity being explored (AAUW, 2004).

Many extra and after school activities (e.g., state science fair, math clubs, 4-H, Mindstorm), provide girls with experiential learning that incorporates problem solving and creativity and design skills as well as providing investigative opportunities into academic areas that are not part of the regular school day. These extracurricular activities play an integral role in shaping interest in STEM subject areas and careers (Bruyere et al., 2009; Darke, Clewell, & Sevo, 2002). In their research on outreach programs, Anderson and Gilbride (2003) determined that participating in an outreach program with a STEM focus significantly increased girls’ interest in pursuing engineering as a career.

The purpose of this study was to determine the extent to which girls’ interest and confidence in two key STEM development areas, problem solving and creativity and design, predict their interest in STEM subject areas. Additionally, we explored in which extracurricular activities girls were involved that had higher levels of participant interest in problem solving and creativity and design.

METHODS

Three research questions guided this study:

1. Is there a statistically significant difference between girls' interest and confidence in a) problem solving, and b) creativity and design?
2. To what extent does a girl's age, *interest* in problem solving and creativity and design, and *confidence* in problem solving and creativity and design, predict their interest in four STEM subject areas: a) science, b) math, c) computer, and d) engineering?
3. Of the extracurricular activities that girls participated in, which activities showed the highest participant mean interest in a) problem solving and b) creativity and design?

Data Collection Procedures and Sample

Data were collected using a 47-item survey instrument developed by the authors to explore the STEM experiences of middle school and high school girls. Questions on the survey instrument were developed based on theory and prior research regarding the experiences of girls in STEM subjects and activities. The instrument includes four sections: experiences in math and science classes related to teaching factors, extracurricular and after-school involvement, interest and confidence in STEM subject and skill areas, and demographics. Surveys were distributed at three career conferences for girls conducted by The Program for Women in Science and Engineering (PWSE) at Iowa State University (ISU). The PWSE K-12 Outreach Program provides STEM outreach programming for over 9,000 K-12 students per year. One of PWSE's signature outreach programs is the *Taking the Road Less Traveled Career Conference for Girls* (TRLT). Three conferences are conducted per semester on the ISU campus for 6th - 12th grade girls, parents, teachers, and counselors.

Prior to the start of conference activities, attendees were asked to voluntarily complete the Girls STEM experiences survey. By completing the survey prior to the start of conference activities, we were able to get a more accurate measure of participants' interest in STEM subjects and skills without the influence of conference activities focused on STEM career awareness. A total of 885 middle school girls and 398 high school girls attended one of the three TRLT conferences with 75% of middle school girls ($n = 629$) and 72% of high school girls ($n = 286$) completing and returning surveys for a 71% overall response rate ($n = 915$). Participants' ages ranged from 11 to 18 ($M = 13.83$, $SD = 1.54$). A frequency distribution of participant demographic characteristics is reported in Table 1.

Table 1: Frequency Distribution for Participant Demographics ($n = 915$)

	<i>n</i>	% of sample
Age		
11	38	4.2
12	136	14.9
13	237	25.9
14	249	27.2
15	105	11.5
16	94	10.3
17	45	4.9
18	11	1.2
Race/Ethnicity		
White	753	82.3
African American	20	2.2
Asian/Pacific Islander	30	3.3
Latina/Hispanic	37	4.0
American Indian/Alaskan Native	9	1.0
Bi-racial/mixed race	46	5.0
Other	20	2.2
Region of Residence		
Rural	316	34.5
Suburban	420	45.9
Urban	118	12.9
Don't Know	61	6.7
School Level		
Middle School	629	68.7
High School	286	31.3

Variables and Analysis

Four dependent variables measuring interest in science, math, computer, and engineering subjects were investigated in this study. Each dependent variable was measured through participants' responses to survey questions asking them to rate their level of interest in each STEM subject area using a Likert-type response scale with 1 = not interested, 2 = slightly interested, 3 = interested, and 4 = very interested.

Independent variables included age (continuous scale), *interest* in problem solving and creativity and design, and *confidence* in problem solving and creativity and design. Interest was measured using the same Likert-type response scale as the dependent variables, and confidence was measured using the following Likert-type response scale where 1 = not confident (I don't think I do well in this activity area), 2 = slightly confident, 3 = confident, and 4 = very confident (I always do well in this activity area).

To answer the first research question, a paired samples *t*-test was used to determine if there was a difference between participants' interest and confidence in a) problem solving and b) creativity and design. Significant differences would help to verify that the concepts of *interest* and *confidence* were measuring different effects on the dependent variables as well as identifying whether participants were more interested than confident or vice-versa in problem solving and creativity and design. The second research question was answered by conducting four hierarchical multiple regression analyses, one for each of the dependent variables of interest in *science*, *math*, *computer*, and *engineering*. In hierarchical regression (sometimes referred to as sequential regression), independent variables are entered in blocks with order of entry specified by the researcher. By entering independent variables in blocks, the effects of each independent variable can be measured at its point of entry (Tabachnick & Fidell, 2007). Three blocks were used for each regression model with the variable of age entered in the first block, followed by the two variables measuring interest in problem solving and interest in creativity and design, and in the final block the two variables measuring confidence in problem solving and confidence in creativity and design.

RESULTS

Initial screening of the data was conducted to ensure assumptions of data normality were met; an important consideration when conducting *t*-tests and multiple regression analyses (Green and Salkind, 2011). Furthermore, bivariate correlations for all independent and dependent variables revealed no instances of multicollinearity. Variables that are multicollinear ($r \geq .90$) contain redundant information and are not needed in the same analysis (Tabachnick & Fidell, 2007). The correlation matrix is shown in Table 2. Because multiple correlations were computed, a Bonferroni approach to control for a Type 1 error was used to determine statistically significant correlations (Green & Salkind). Thus, $p < .0013 (.05/36)$ was used to identify statistically significant correlations noted with an asterisk (*) in Table 2.

Table 2: Correlation Matrix – Independent and Dependent Variables ($n = 915$)

	1	2	3	4	5	6	7	8
1 Age	--							
2 Interest in Problem Solving	-.01	--						
3 Confidence in Problem Solving	-.07	.66*	--					
4 Interest in Creativity & Design	-.16*	.22*	.17*	--				
5 Confidence in Creativity & Design	-.20*	.17*	.29*	.67*	--			
6 Science Interest	.04	.27*	.19*	-.02	.03	--		
7 Math Interest	-.03	.43*	.31*	.06	.02	.25*	--	
8 Computer Interest	-.08	.20*	.12*	.17*	.14*	.13*	.28*	--
9 Engineering Interest	-.05	.29*	.23*	.15*	.12*	.28*	.27*	.27*

Note: * $p < .0013$ Bonferroni adjustment for multiple correlations to minimize chances of a Type 1 error.

Noteworthy are the statistically significant correlations between age and a) interest in creativity and design ($r = -.16$, $p < .0013$) and b) confidence in creativity and design ($r = -.20$, $p < .0013$) indicating that as girls get older they are less interested and confident in creativity and design.

Difference between Interest and Confidence

Results of the two paired samples *t*-tests indicated statistically significant differences between girls' interest and confidence for both problem solving and creativity and design. Specifically, girls in this study reported more confidence ($M = 2.80$, $SD = .891$) than interest ($M = 2.74$, $SD = .946$) in problem solving, $t(967) = 2.67$, $p = .008$. In the second paired samples *t*-test, girls in this study reported more interest ($M = 3.30$, $SD = .843$) than confidence ($M = 3.08$, $SD = .901$) in creativity and design, $t(963) = 9.86$, $p < .001$.

Predictors of Interest in STEM Subject Areas

Results of the four regression models are summarized in Table 3 with standardized Beta (β) coefficients listed for independent variables in each block. For each of the dependent variables in the full model, *interest* in problem solving was the only positive predictor that was statistically significant across all four regression models. *Interest* in creativity and design was a positive predictor for interest in computers and in engineering, but a negative predictor for interest in science. The variables of *confidence* in problem solving and creativity and design, as well as the variable of age, were not statistically significant predictors for interests in any of the STEM subject areas. Following are summative results for each of the four regression models.

Table 3: Standardized Regression Coefficients for Interest in STEM Subject Areas ($n = 915$)

Variables	Science	Math	Computers	Engineering
<i>Block 1</i>				
Age	.044	-.032	-.083*	-.052
<i>Block 2</i>				
Age	.036	-.031	-.061	-.035
Interest in Problem Solving	.285***	.442***	.175***	.275***
Interest in Creativity & Design	-.074*	-.037	.126***	.084**
<i>Block 3 (Full Model)</i>				
Age	.044	-.035	-.060	-.032
Interest in Problem Solving	.275***	.407***	.210***	.237***
Interest in Creativity & Design	-.116**	.013	.100*	.086*
Confidence in Problem Solving	.012	.057	-.056	.059
Confidence in Creativity & Design	.064	-.081	.043	-.004
<i>Full Model Statistics</i>				
R^2	.082	.194	.065	.097
Adjusted R^2	.077	.190	.059	.092

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Model 1: Interest in Science

The full model significantly predicts 8% of the variance for interest in science, $F(5, 909) = 16.25$, $p < .001$ with interest in problem solving ($\beta = .275$, $p < .001$) as a positive predictor and interest in creativity and design ($\beta = -.116$, $p < .001$) a negative predictor. Results indicate that girls who are interested in problem solving are more likely to be interested in science; however, girls who are interested in creativity and design are less likely to be interested in science.

Model 2: Interest in Math

The full model significantly predicts 19% of the variance for interest in math, $F(5, 909) = 43.89$, $p < .001$. In block 2 and in the full model, interest in problem solving ($\beta = .407$, $p < .001$) was the only statistically significant predictor for interest in math.

Model 3: Interest in Computer

The full model significantly predicts 6% of the variance for interest in computer, $F(5, 909) = 12.54$, $p < .001$. In the first block, age ($\beta = -.083$, $p < .001$) was a significant negative predictor suggesting that as girls get older they are less likely to be interested in computers. However, age dropped out of statistical significance in the second

and third blocks. In the full model, both interest in problem solving ($\beta = .210, p < .001$) and interest in creativity and design ($\beta = .100, p < .05$) predicted greater interest in computers.

Model 4: Interest in Engineering

The full model significantly predicts 9% of the variance for interest in engineering, $F(5, 909) = 19.56, p < .001$. Once again, both interest in problem solving ($\beta = .237, p < .001$) and interest in creativity and design ($\beta = .086, p < .05$) positively predicted greater interest in engineering, although interest in creativity and design to a lesser extent than interest in problem solving.

Extracurricular Involvement

The overarching goal of K-12 STEM outreach programs is to create an awareness of STEM opportunities and foster interest in pursuing, persisting, and graduating with a STEM degree, and finally choosing a STEM career post-graduation. K-12 STEM outreach programs may find it beneficial to know the extracurricular involvement of girls who are more interested in problem solving and creativity and design. Outreach efforts can then be specialized and targeted to specific extracurricular activities. Furthermore, encouraging girls who are not already participating in these programs to participate may foster interest in problem solving and creativity and design potentially leading to an increased interest in STEM subjects.

Figure 1 provides participants' mean interest for problem solving by activity. The top five activities that had the highest participant mean interest in problem solving were 1) State Science Fair, 2) Project Lead the Way, 3) environmental clubs, 4) math clubs, and 5) Future Farmers of America. The activities with the lowest participant mean interest in problem solving included sports/athletics and band/music.

Interest in Problem Solving

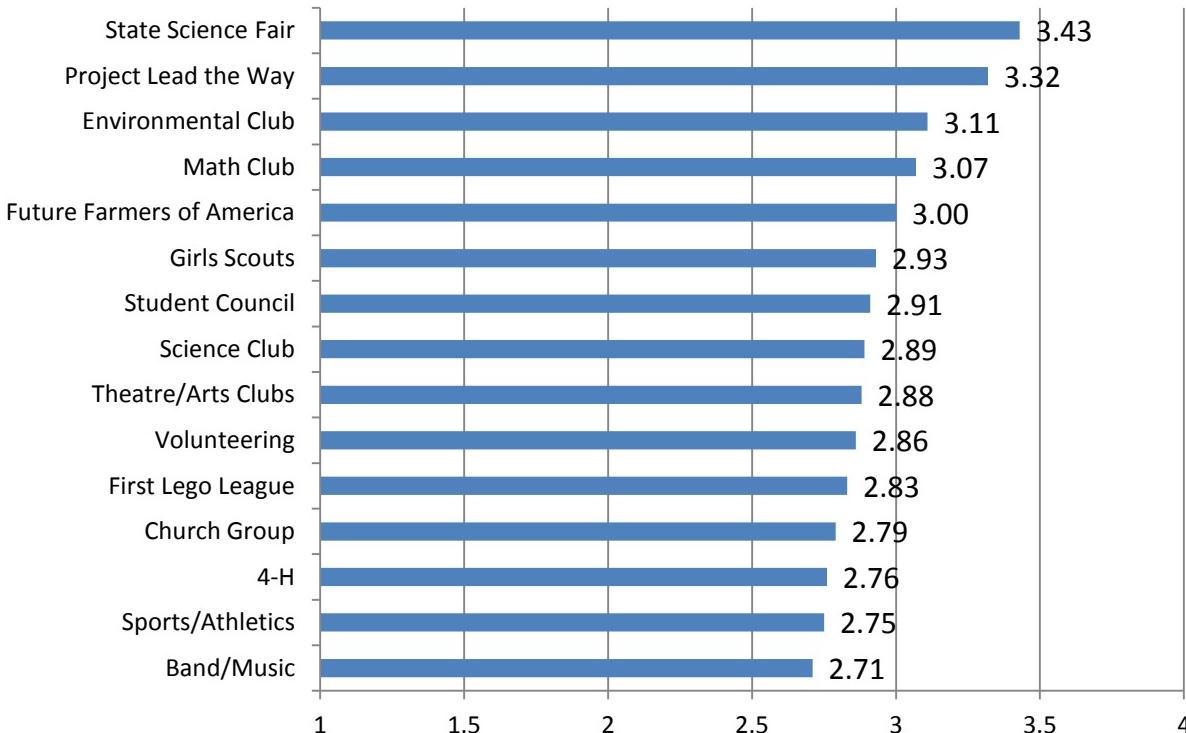


Figure 1. Participants' Mean Interest in Problem Solving by Activity

Figure 2 illustrates participants' mean interest for creativity and design by activity. The top five activities with the highest participant mean interest in creativity and design were 1) Student Council, 2) State Science Fair, 3) volunteering, 4) environmental clubs, and 5) math club. The activities with the lowest participant mean interest in creativity and design included Future Farmers of America and Project Lead the Way.

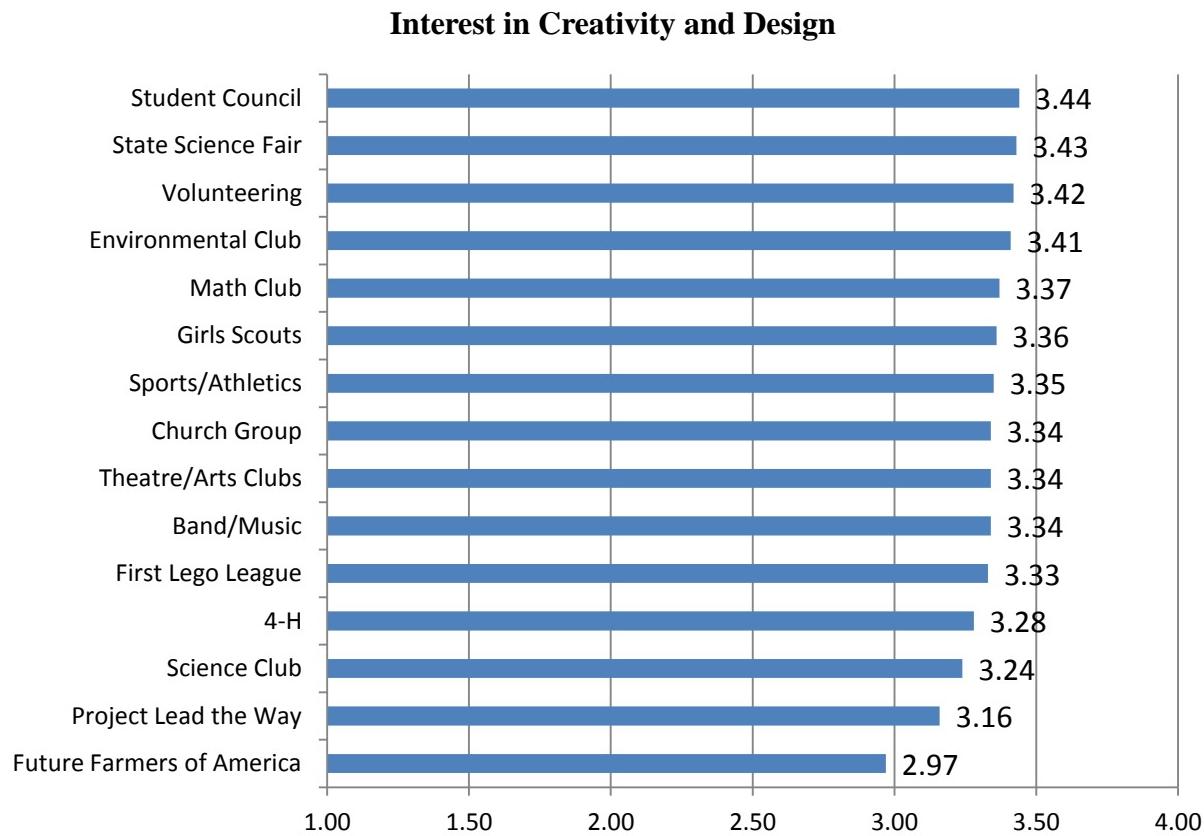


Figure 2. Participants' Mean Interest in Creativity and Design by Activity

DISCUSSION AND CONCLUSION

According to The National Academy of Engineering (2008), it is important for students to begin associating the possibilities in STEM fields with the need for creativity and real world problem solving skills. The primary focus of this research was to determine the extent to which middle and high school girls' interest and confidence in two fundamental aptitudes for STEM professionals (problem solving, and creativity and design) influence their interest in STEM subjects. Our findings indicate that girls interested in problem solving are likely to be interested in all four STEM subject areas. These results support Modi et al.'s (2012) conclusion that girls who are interested in STEM also indicated an interest in problem solving. Interest in creativity and design was also a significant predictor for interest in computer and engineering subjects. This outcome may be a positive result from programs (e.g., Engineer Your Life, PWSE) implementing the messaging initiatives put forth in *Changing the Conversation: Messages for Improving Public Understanding of Engineering* (NAE, 2008).

Providing opportunities and developing curriculum that foster girls' interest in problem solving skills is a necessity to further their interest in STEM subjects, college degree programs, and careers. In a recent survey of engineering freshman, students cited the top reasons for what interested them in an engineering degree as "innovation/creativity/design, building things, math/science, practical/real world applications, knowing how things work, and problem solving" (Mertz, 2012, p. 1). Our research supports an approach to cultivating interest in STEM subjects through instructional strategies that involve problem solving experiences (i.e., PBL, PBS, anchored instruction). It is well known that girls have historically chosen careers that have a positive social impact ("helping

fields"). Using pedagogical strategies like PBL provide students with a collaborative opportunity to solve a complex, realistic or real-world problem that not only motivates students to learn, but results in the formation of a relevant solution. This real-world problem solving approach creates that much needed link between STEM professions and careers that have positive social impact. In addition, STEM careers require the synergy of cross-disciplinary knowledge. Engaging girls using problem solving based strategies fosters the ability to develop and enhance this transferable skill.

Future Research

A somewhat unanticipated result in the regression analyses was that interest in creativity and design was a statistically significant negative predictor for girls' interest in science, while interest in creativity and design was a positive predictor for interest in computers and engineering subject areas. Additional research should be conducted to further investigate the disconnect between middle school and high school girls' interest in creativity and design and their interest in science.

What was not addressed in this research study is the extent to which different problem solving approaches to learning (i.e., PBL, PBS, anchored instruction) impacted girls' interest in the STEM subject areas. In other words, is there a problem solving pedagogical approach that works best in fostering interest in STEM subject areas.

Additional research should continue to look at age as a variable for interest in the STEM subject areas. Past research has indicated that girls' interest in STEM subject areas declines as girls get older (AAUW, 1998; Brotman & Moore, 2008; Catsambis, 1995; Fennema, 2000; Hebert & Stipek, 2005). In this study, bivariate correlations showed statistically significant relationships between age and interest and confidence in creativity and design, but regression results indicated that age was not a significant predictor for interest (or declining interest) in any of the STEM subject areas.

Finally, additional research should look further into the relationship between interest in problem solving and creativity and design and those after and extracurricular school programs identified with the highest participant mean interests in problem solving and creativity and design. To what extent do girls participate in activities like State Science Fair, Project Lead the Way, environmental club, and math club because they use problem solving skills in their activities or do the girls who participate in these activities develop interest in problem solving because of the activities themselves. And the same questions arise for the relationship between interest in creativity and design and student council, State Science Fair, volunteering, and environmental club. Furthermore, some activities that indicated high participant interest in problem solving indicated the lowest levels of interest in creativity and design (e.g., Project Lead the Way).

AUTHOR INFORMATION

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